

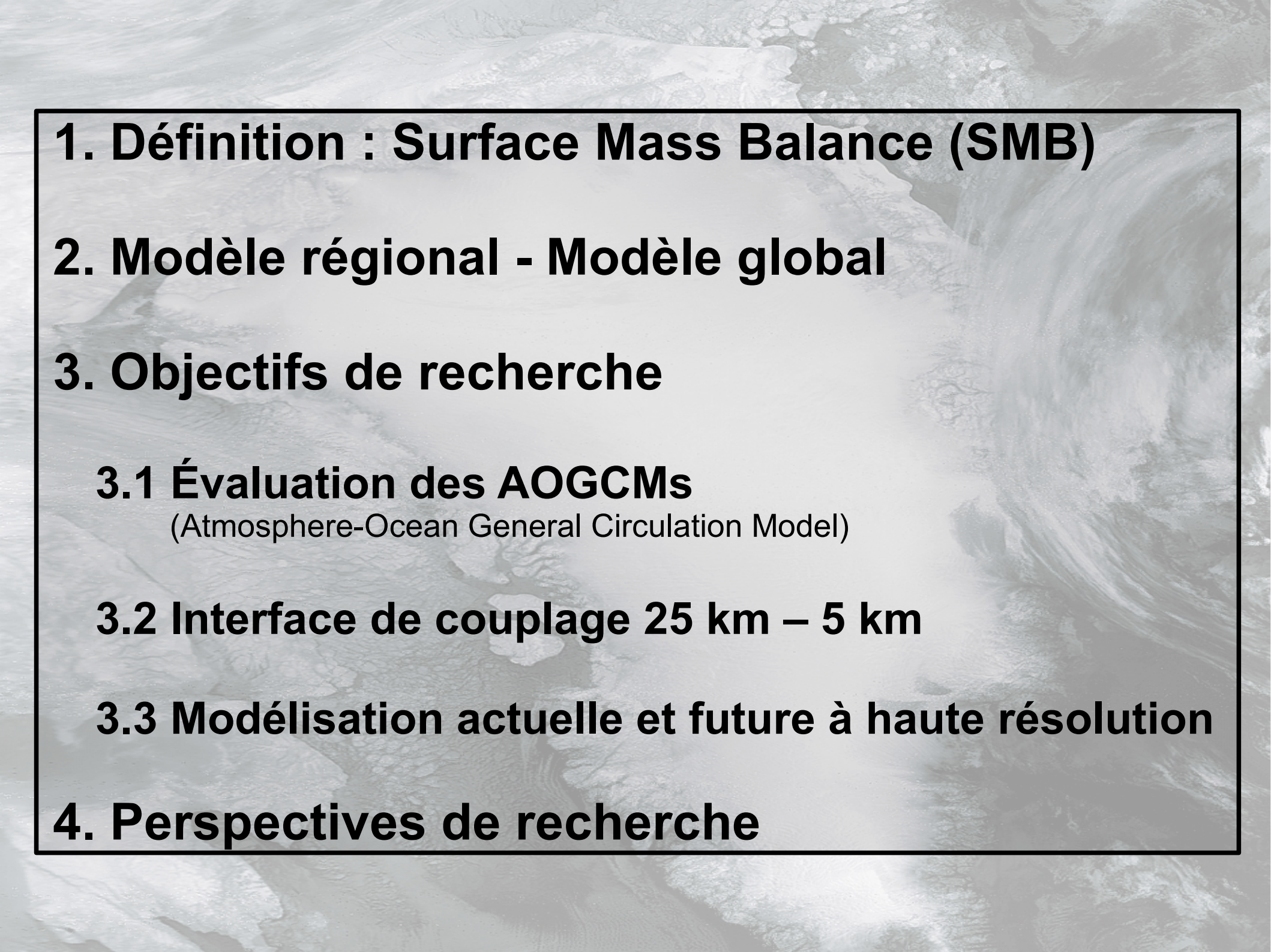
CENTRE GEOSCIENCES

**1^{ère} journée des doctorants
21 janvier 2010**

**Modélisation à haute résolution de l'impact
actuel et futur du réchauffement climatique
sur le bilan de masse en surface de la calotte
glaciaire du Groenland**

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Promoteurs :
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1. Définition : Surface Mass Balance (SMB)

2. Modèle régional - Modèle global

3. Objectifs de recherche

3.1 Évaluation des AOGCMs

(Atmosphere-Ocean General Circulation Model)

3.2 Interface de couplage 25 km – 5 km

3.3 Modélisation actuelle et future à haute résolution

4. Perspectives de recherche

1. Définition : Mass Balance

Ice sheet Mass Balance \approx **accumulation** – **ablation**

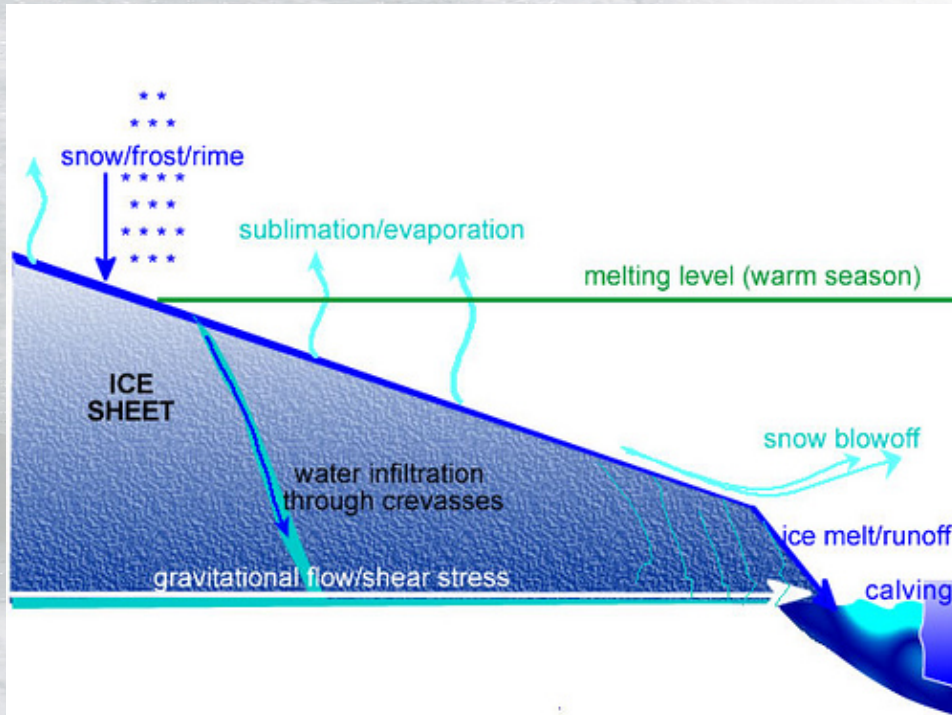
snowfall (solid precipitation)
- **evaporation/sublimation**

runoff \approx liquid water production
(melt and rainfall)
- **meltwater retention**

iceberg calving

basal melting

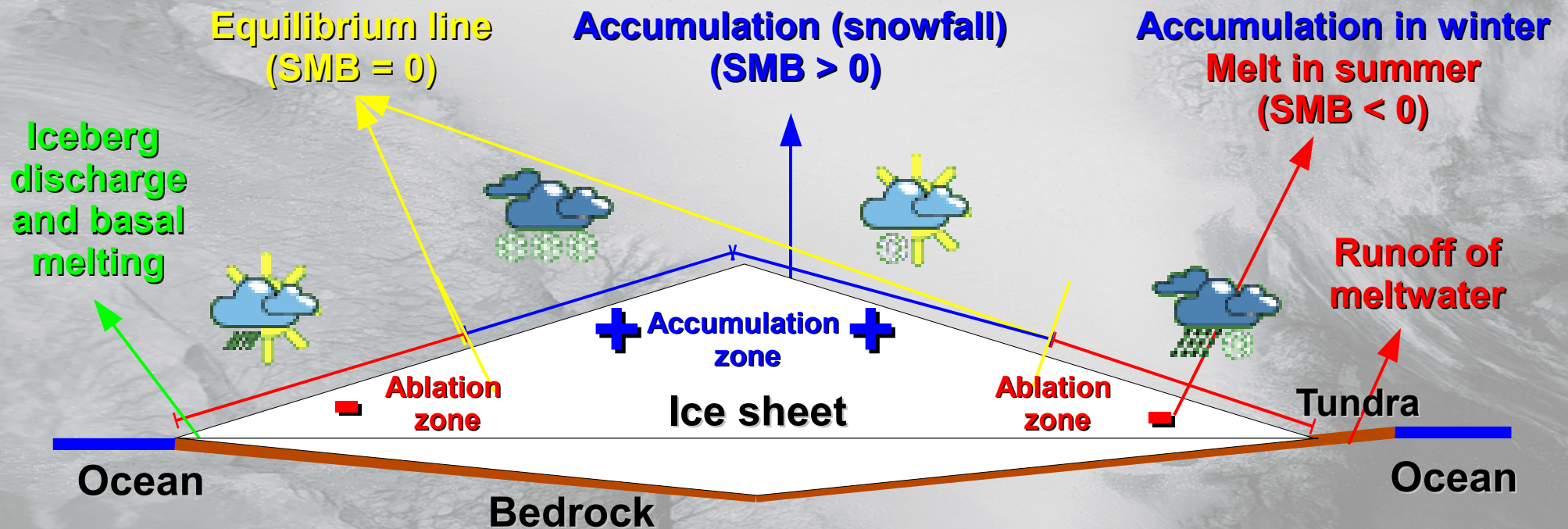
flux of drifting snow



ice shelves

1. Définition : Surface Mass Balance (SMB)

Surface Mass Balance \approx **accumulation** – **runoff of meltwater**



drifting snow
ice dynamic

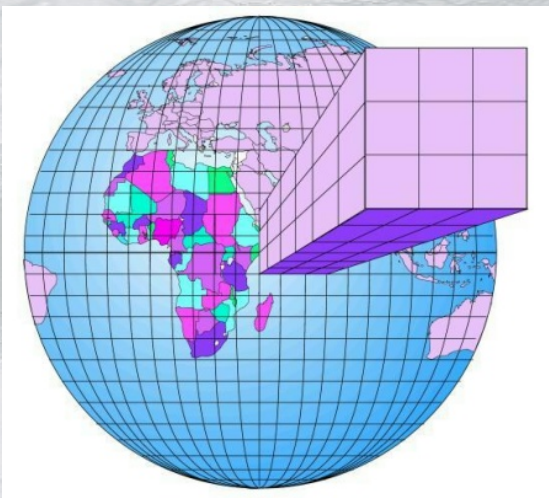
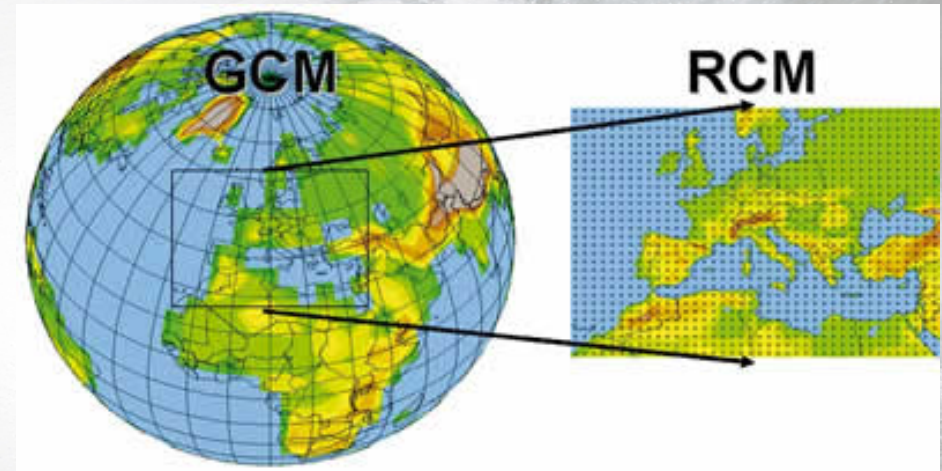
2. Modèle régional – Modèle global

Regional Climate Model (RCM)

- **Meilleure résolution spatiale**
 - topographie détaillée
 - phénomènes locaux
 - temps de calcul
- **Paramétrisation spécifique**
 - physique adaptée

Global Circulation Model

Regional Climate Model



Forçage aux frontières du domaine par :

- Global Circulation Model (GCM)
- RCM à plus faible résolution
- observations

→ RCM dépendant des champs de forçage

3. Objectifs de recherche

3.1 Atmosphere – Ocean General Circulation Model (AOGCMs)

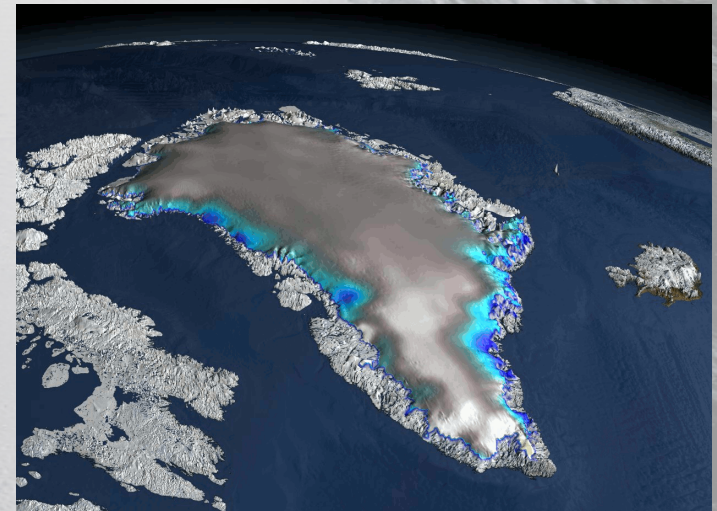
- période 1970-1999 : paramètres de surface + circulation atmosphérique
- période 2070-2099 : greenhouse gaz emissions scenarios (IPCC AR4)

3.2 MAR (Modèle Atmosphérique Régional)

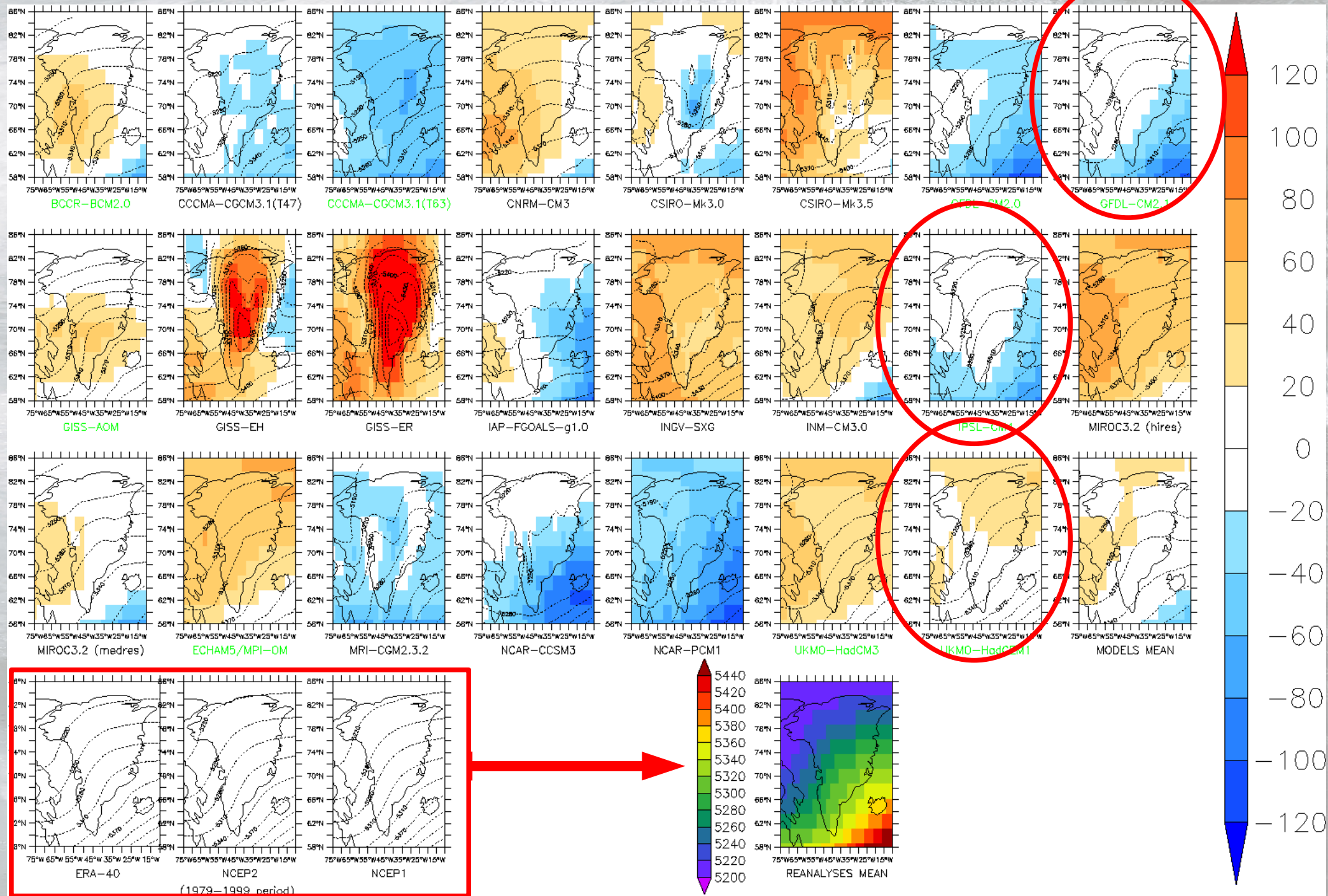
- interface de couplage 25 km → 5 km
- simulation du SMB actuel

3.3 Simulations futures

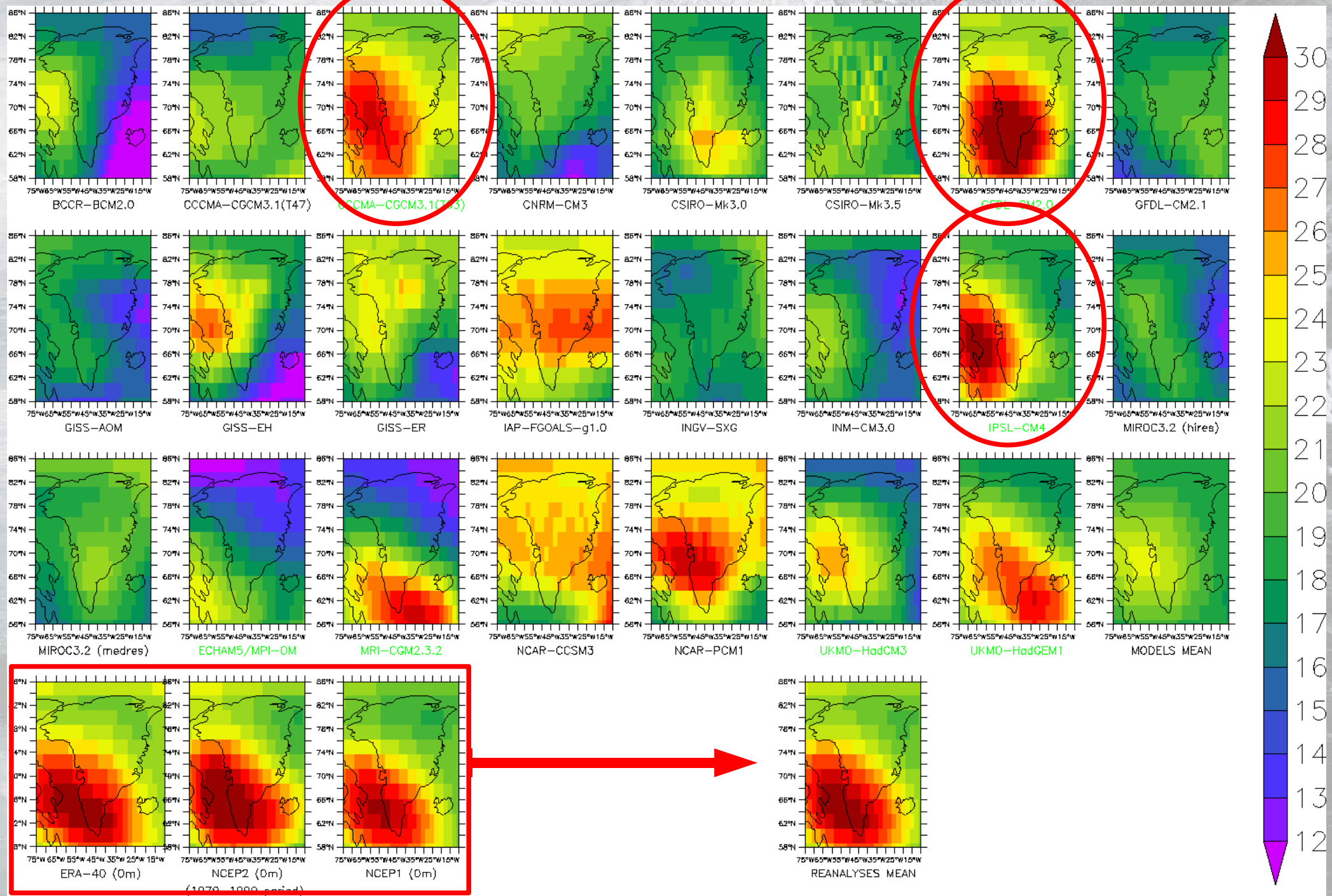
- forçage du MAR par AOGCMs
- avec interface de couplage



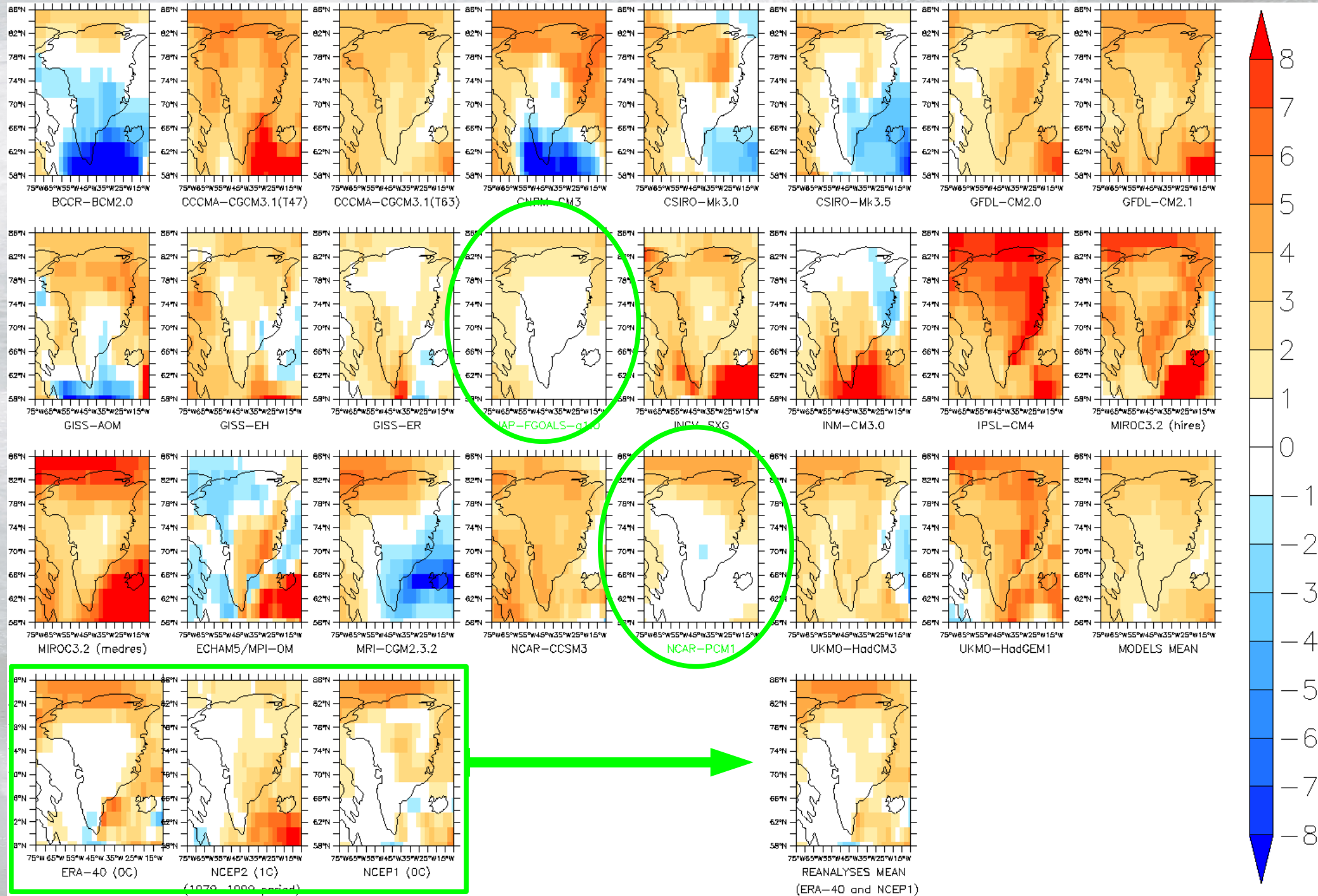
3.1 AOGCMs: regional atmospheric circulation



3.1 AOGCMs: North Atlantic Oscillation (NAO)

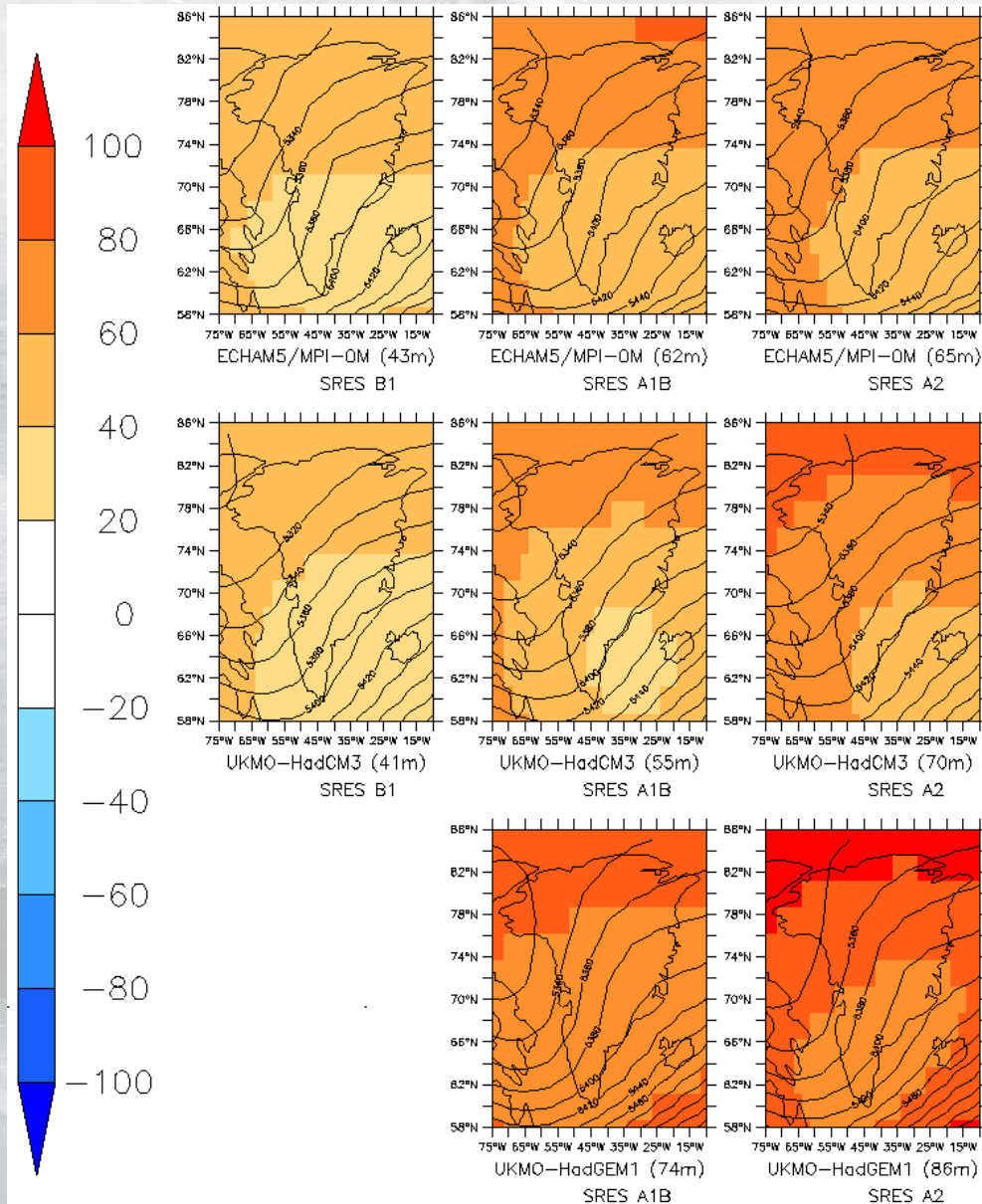


3.1 AOGCMs: temperature trends (1970-1999)



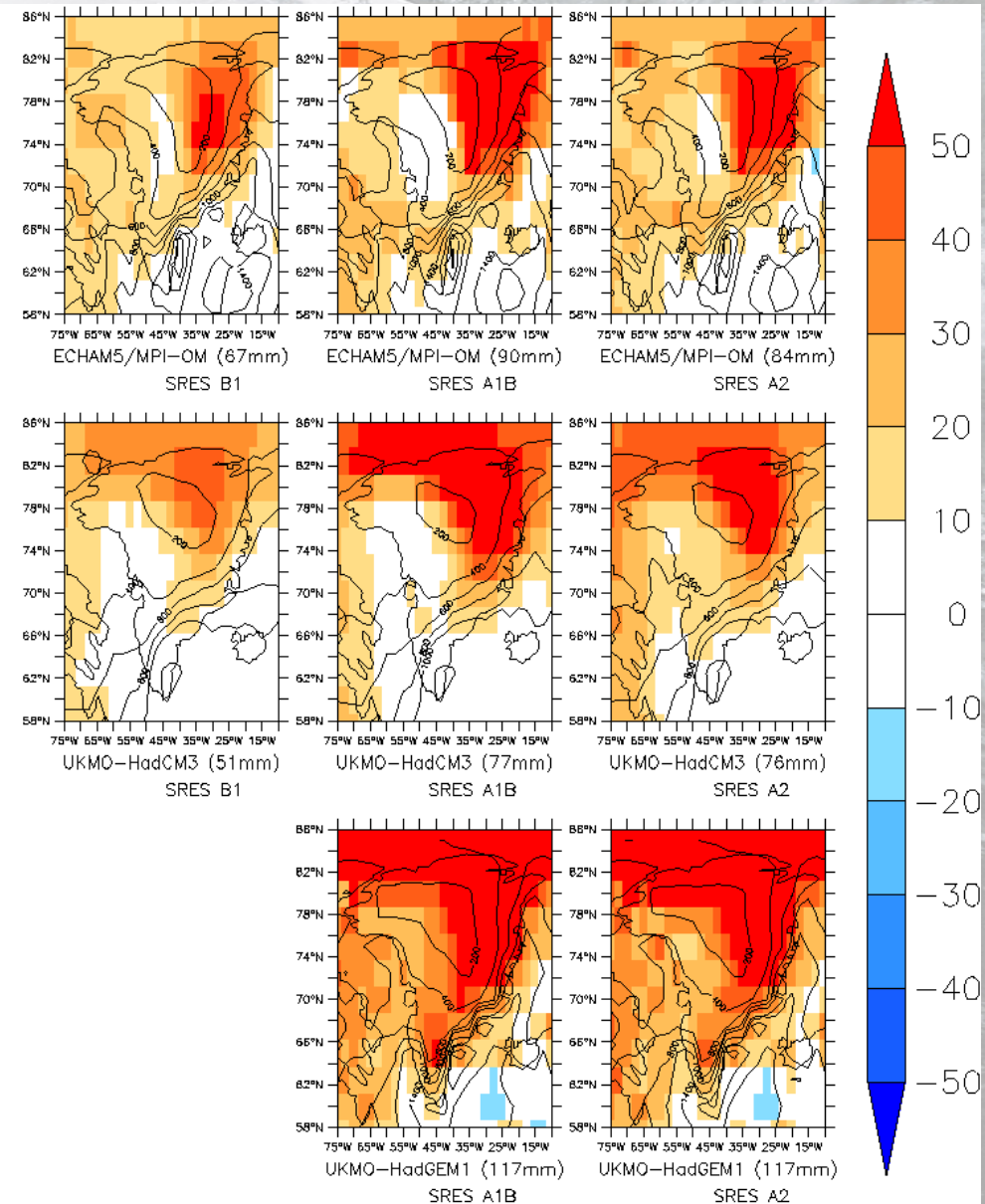
3.1 AOGCMs: greenhouse gas emissions scenarios (2070-2099)

Annual 500hPa geopotential height anomalies (m)



a) Annual 500hPa geopotential height anomalies (m)

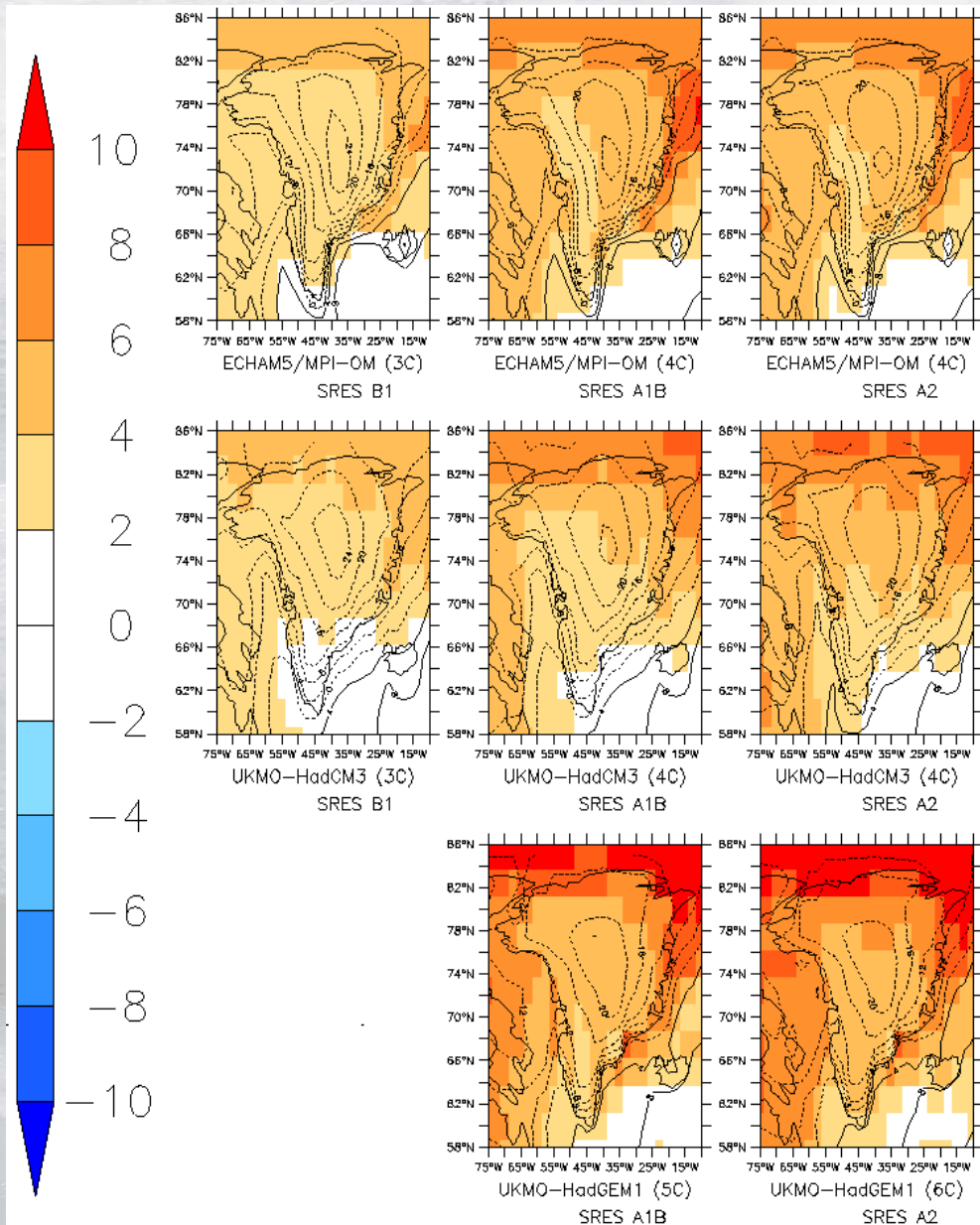
Annual precipitation anomalies (mm)



b) Annual precipitation anomalies (mm)

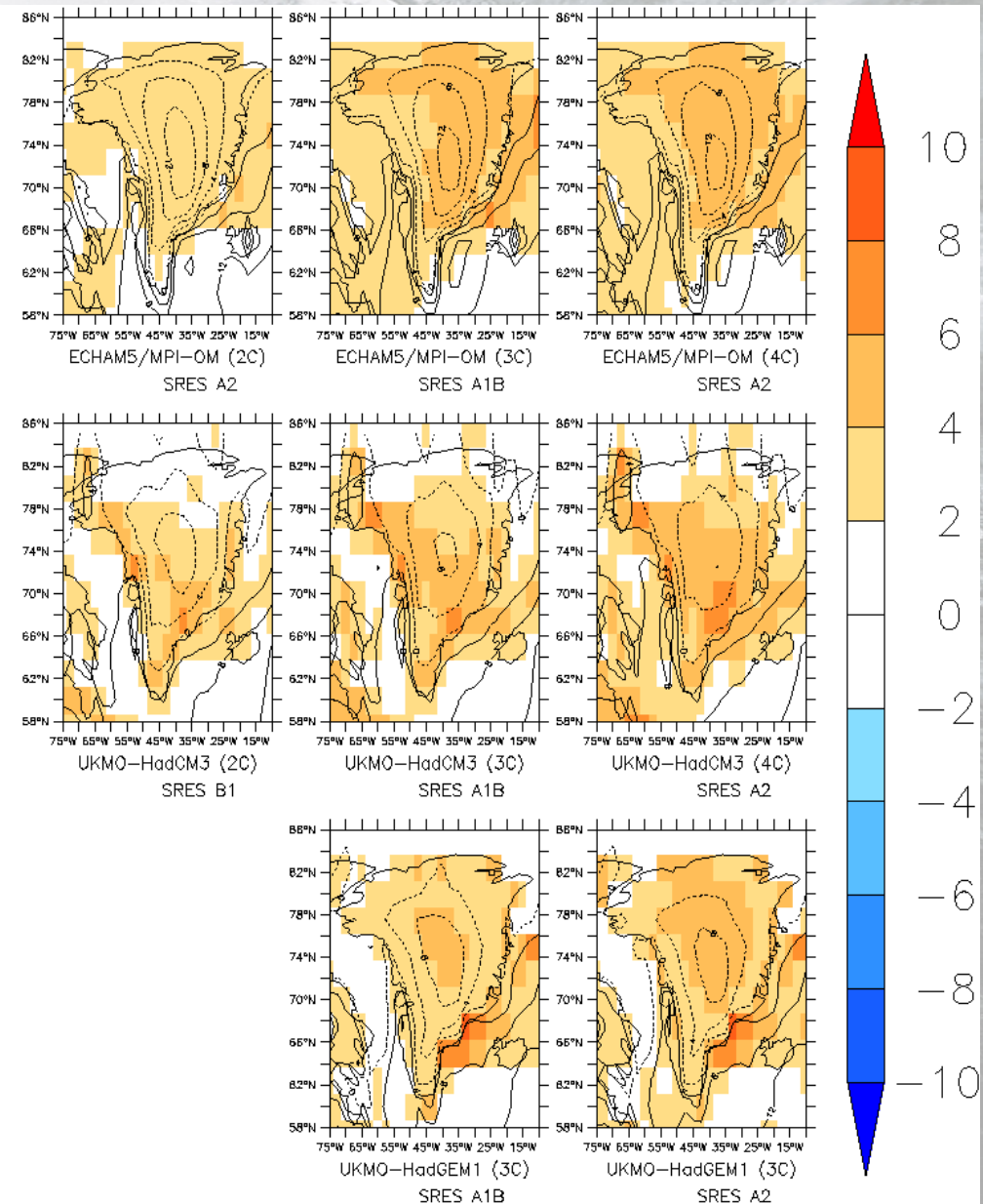
3.1 AOGCMs: greenhouse gas emissions scenarios (2070-2099)

Annual near surface temperature anomalies (°C)



a) Annual near surface temperature anomalies (°C)

Summer near surface temperature anomalies (°C)



b) Summer near surface temperature anomalies (°C)

3.2 Interface de couplage 25 km → 5 km

MAR (Modèle Atmosphérique Régional)

Hubert Gallée (LGGE, France)

- (non-)hydrostatic primitive equation model
- vertical coordinate is the normalized pressure sigma

Domain: 80 x 140 grid points
(2000 x 3500 km)

Resolution: 25 km

Time step: 150 s

1st atm. level: 3 m

Verticals levels:

Atmosphere (MAR) 30 levels

Snow (SISVAT) 20 levels

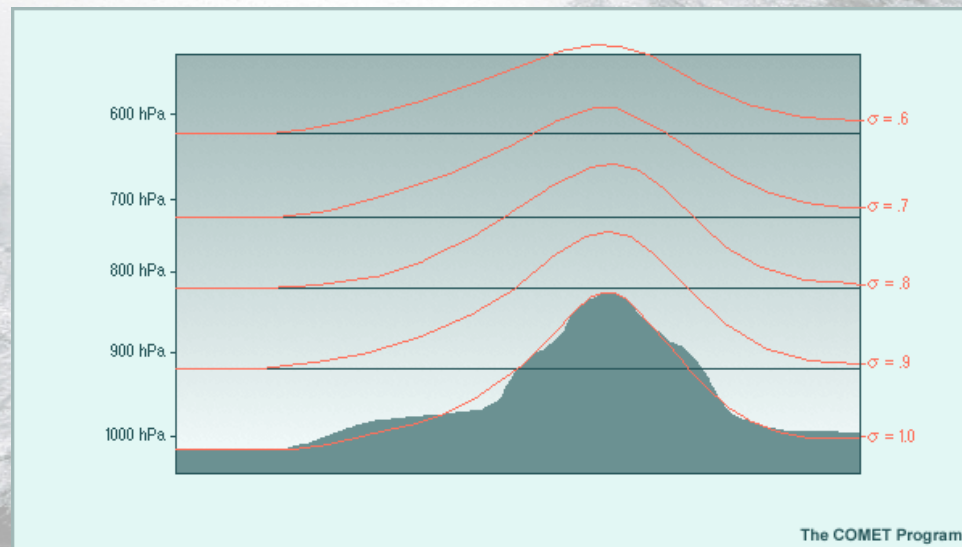
Tundra (SISVAT) 7 levels

Forcing:

Lateral boundaries Reanalysis 6-h

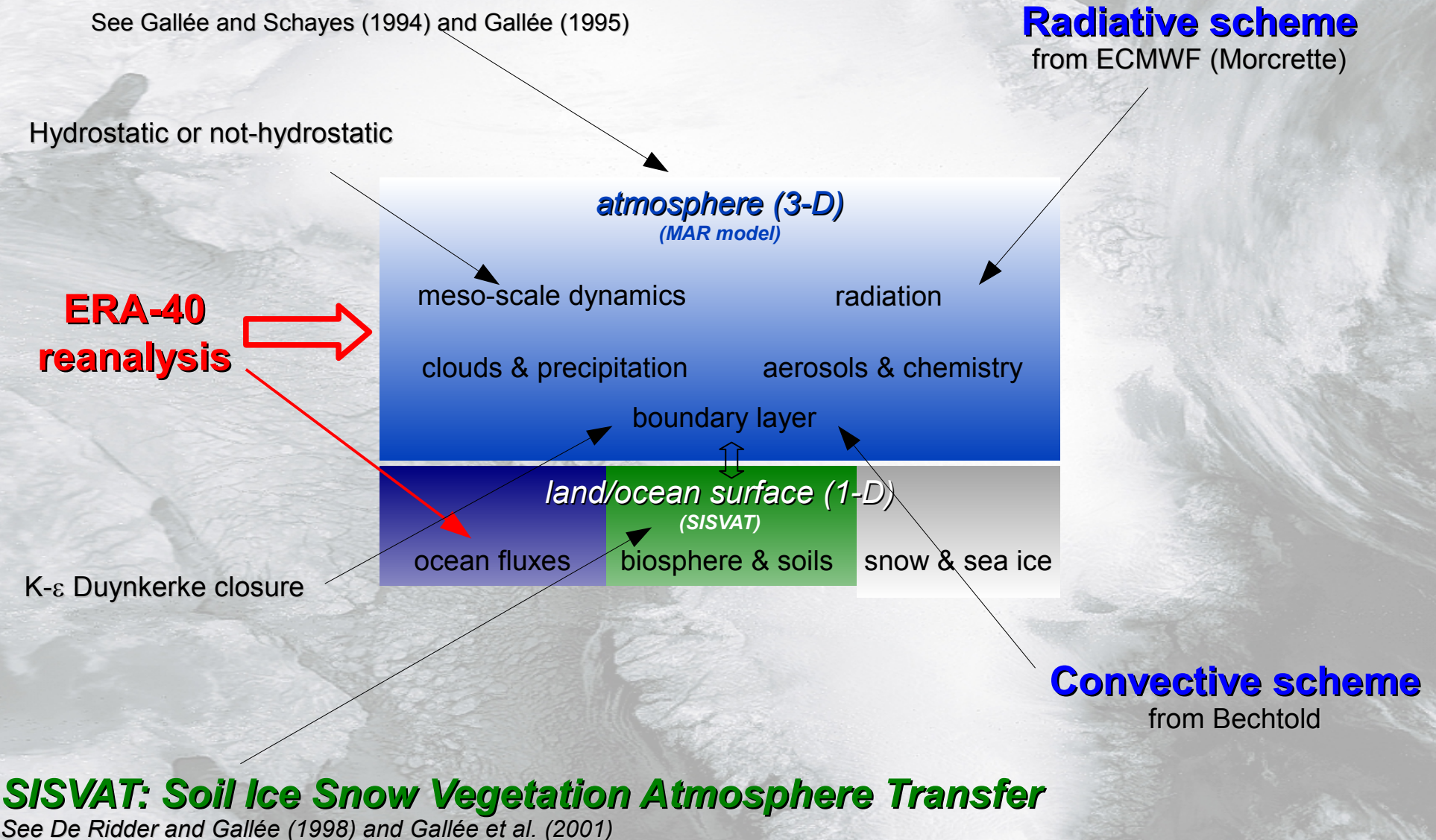
SSTs Reanalysis 6-h

Sea ice Reanalysis 6-h



The COMET Program

3.2 Interface de couplage 25 km → 5 km



3.2 Interface de couplage 25 km → 5 km

MAR

Two - Way Nesting



*solar & infrared radiative fluxes
turbulent momentum fluxes
sensible & latent heat fluxes*

displacement height
roughness length
root fraction
min. stomatal resistance
global plant resistance
canopy spatial distrib.
canopy temporal evol.

**soil-vegetation
module**

SISVAT

**snow-ice
module**

12
plant
types

1 veg. layer



20 snow-ice
layers

snow & ice

temperature
density
liquid water cont.
grain size
dendricity
sphericity
ages
ice lens

surface albedo
4 soil types

7 soil layers (thinnest = 2 mm, deepest = 2.888 m)

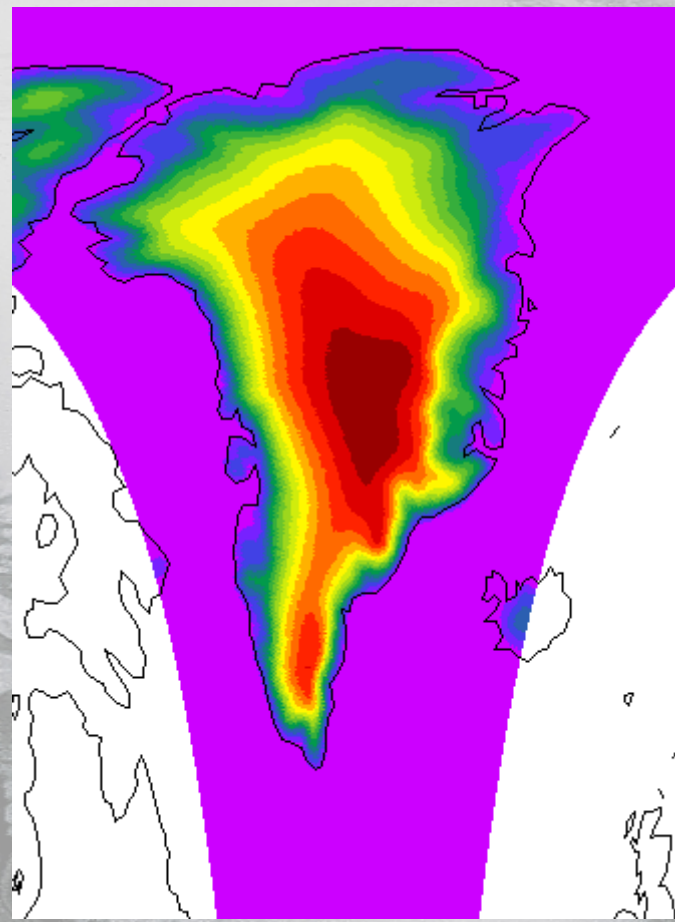
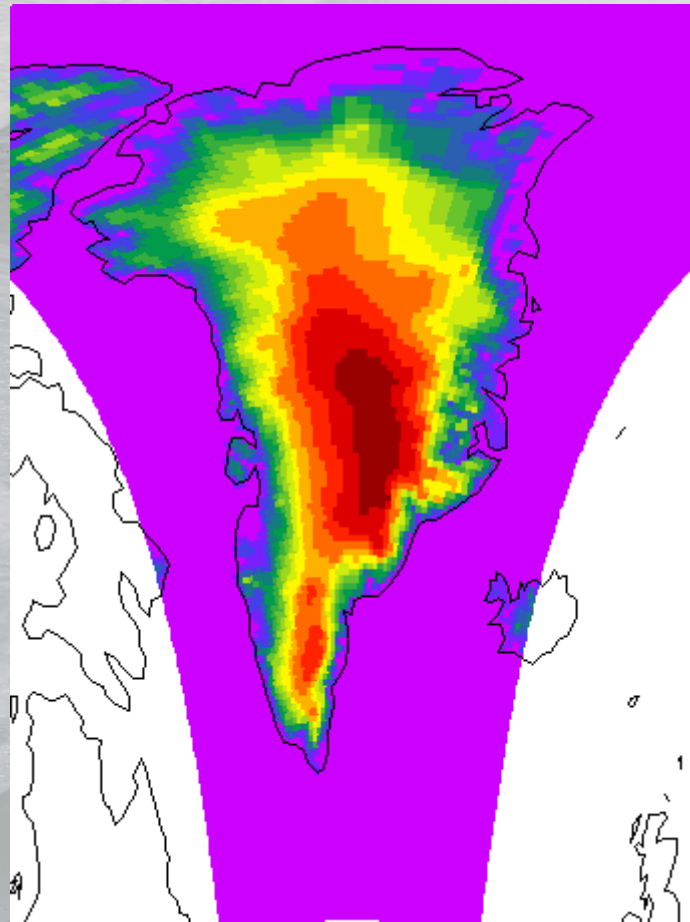
saturated water content
water potential at sat.
hydraulic conductivity at sat.
exponent of the water
retention curve



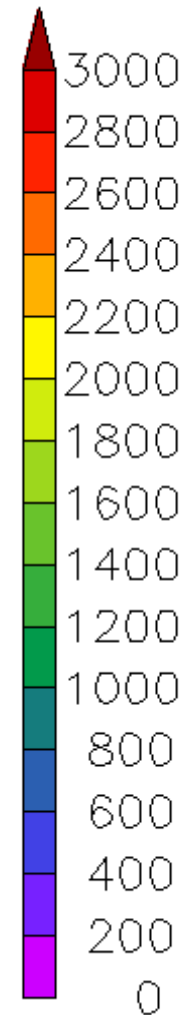
**Ocean and sea-ice concentration
from ECMWF reanalysis**

3.2 Interface de couplage 25 km \rightarrow 5 km

Topographie interpolée

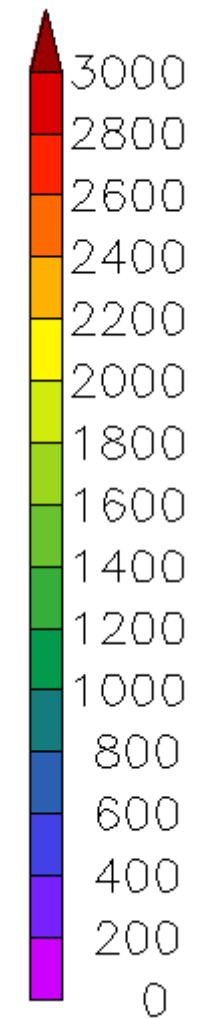
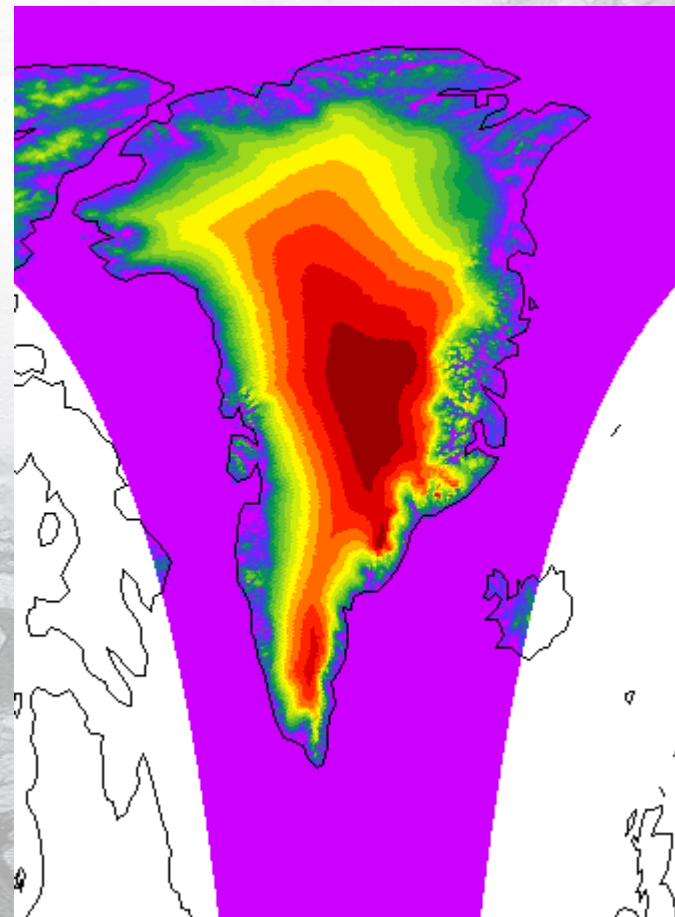
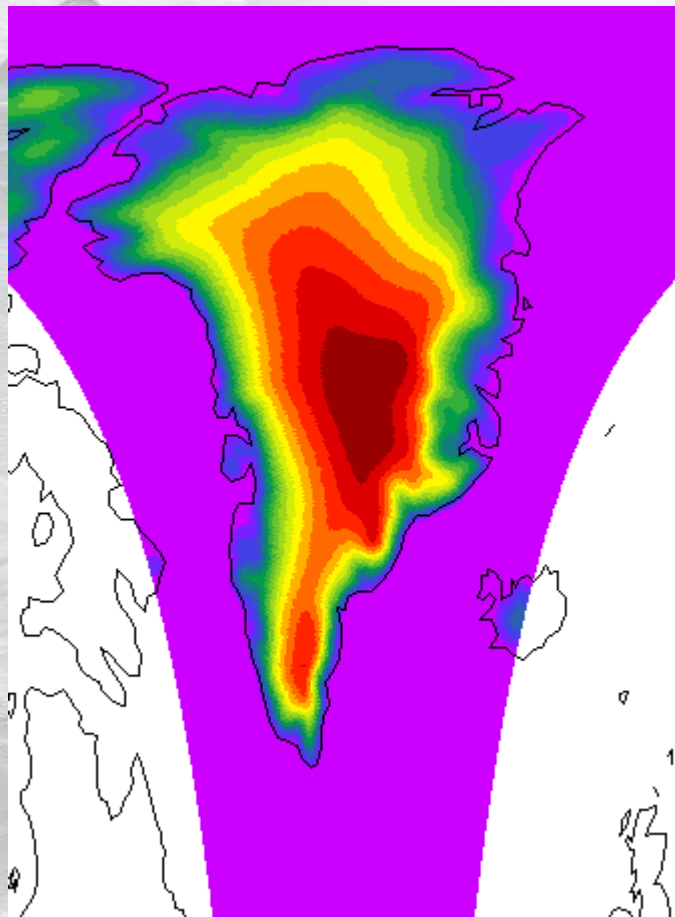


25 km \longrightarrow 5 km



3.2 Interface de couplage 25 km \rightarrow 5 km

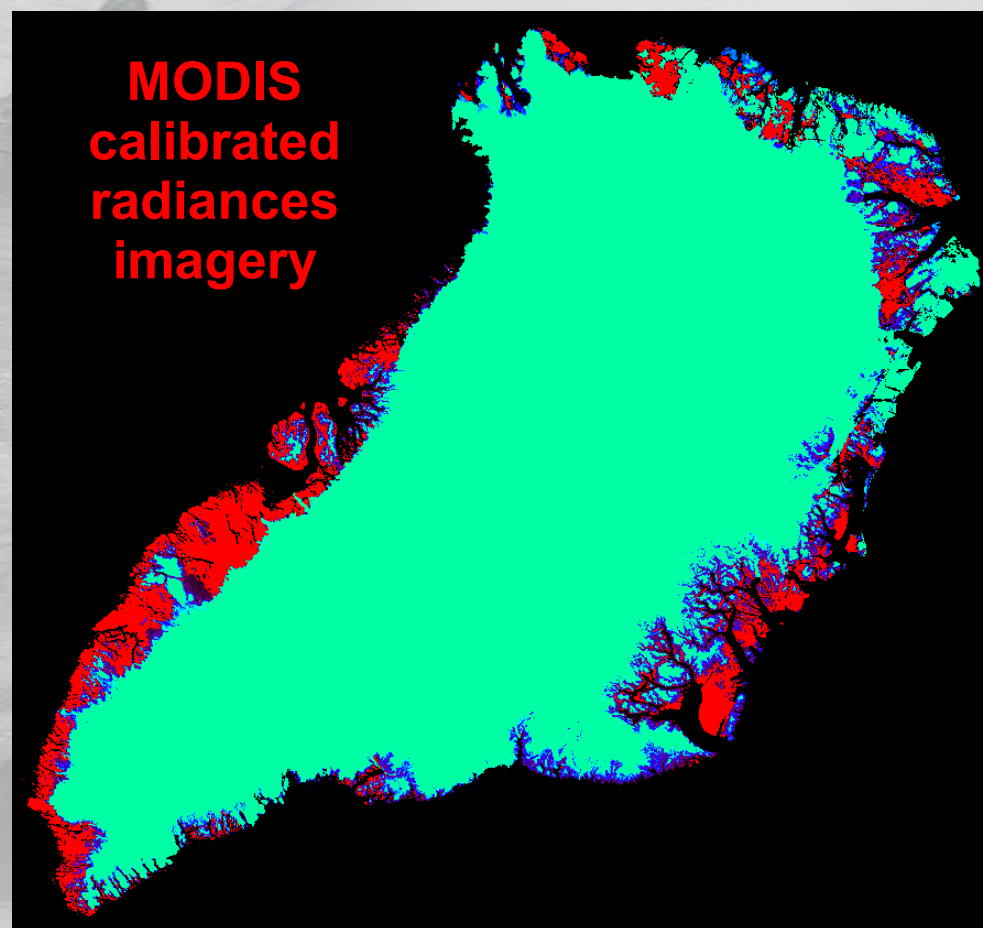
Topographie améliorée (J. Bamber)



5 km \longrightarrow 5 km

3.2 Interface de couplage 25 km \rightarrow 5 km

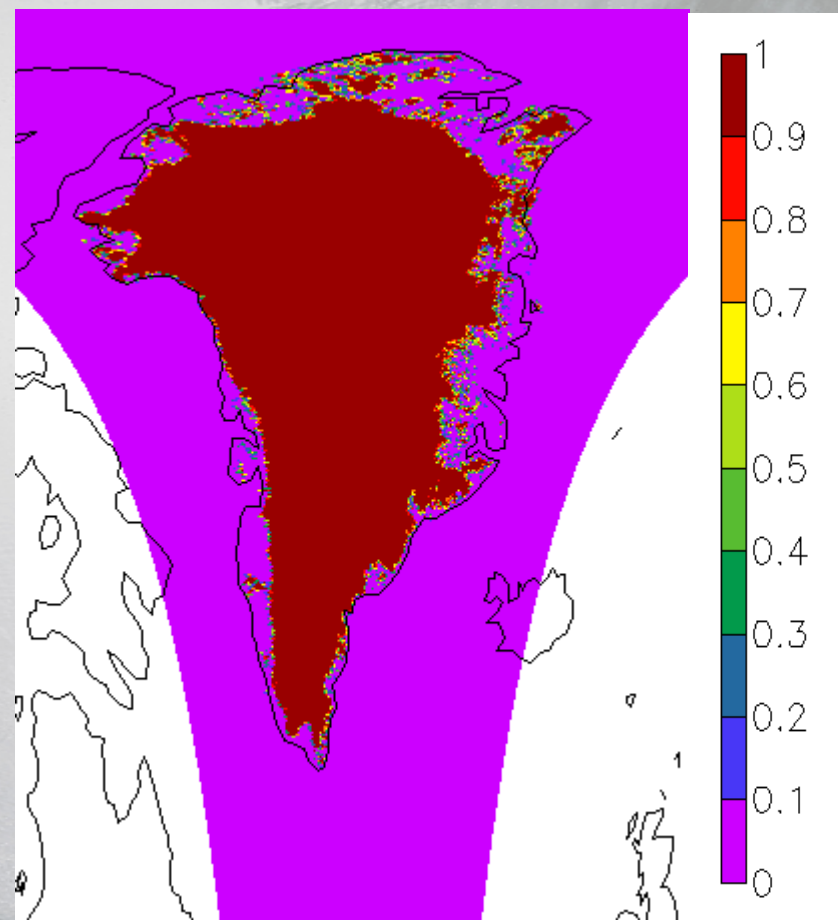
Application d'un masque (J. Box)



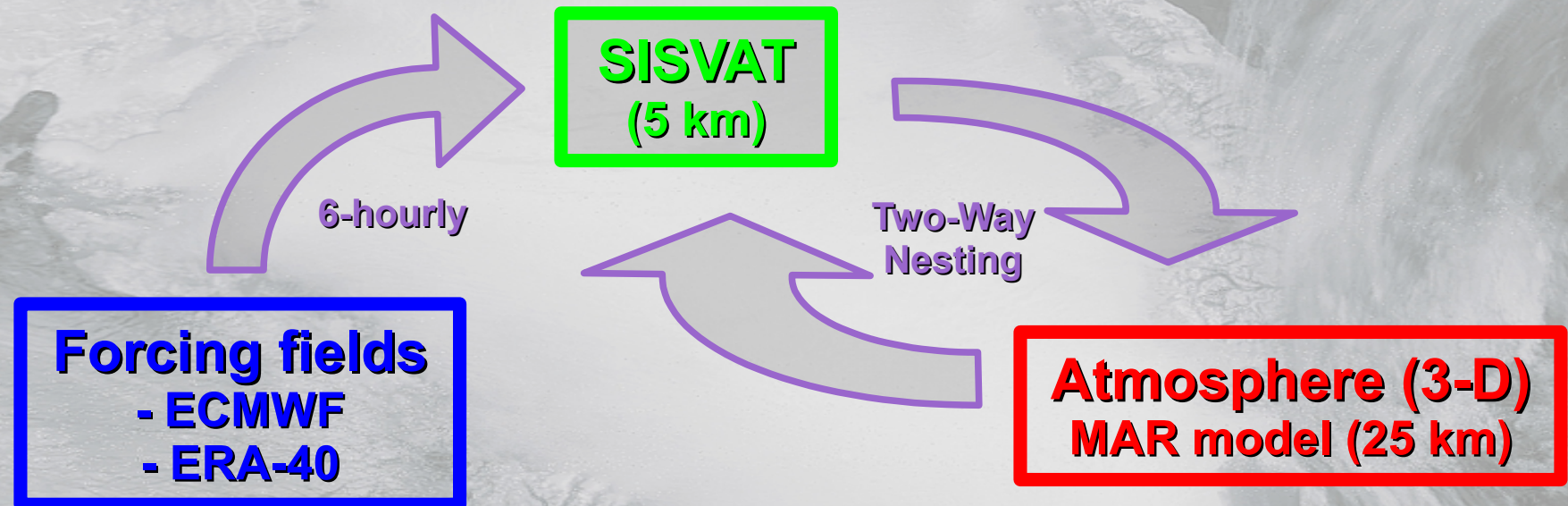
1.25 km



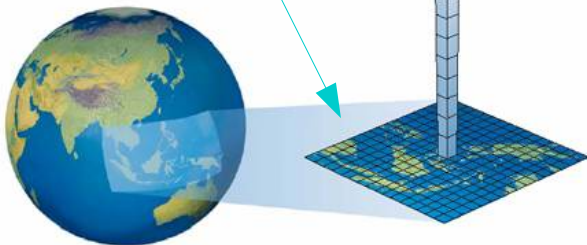
5 km



3.2 Interface de couplage 25 km \rightarrow 5 km



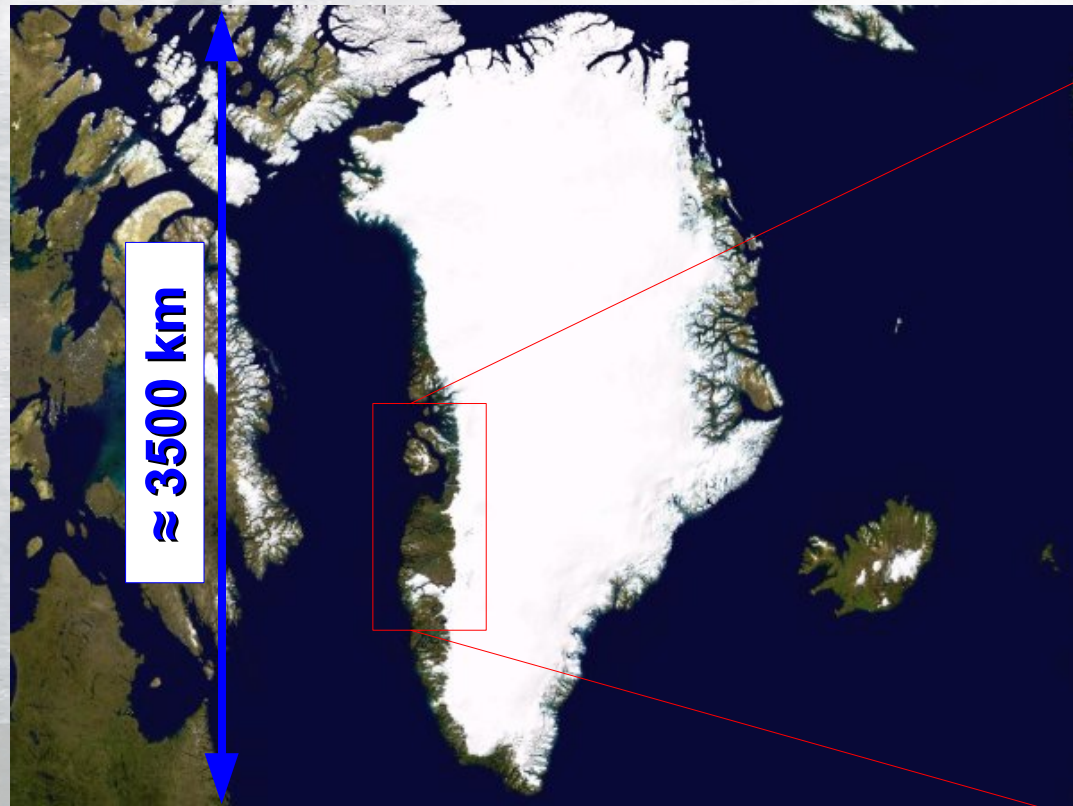
Temps de calcul



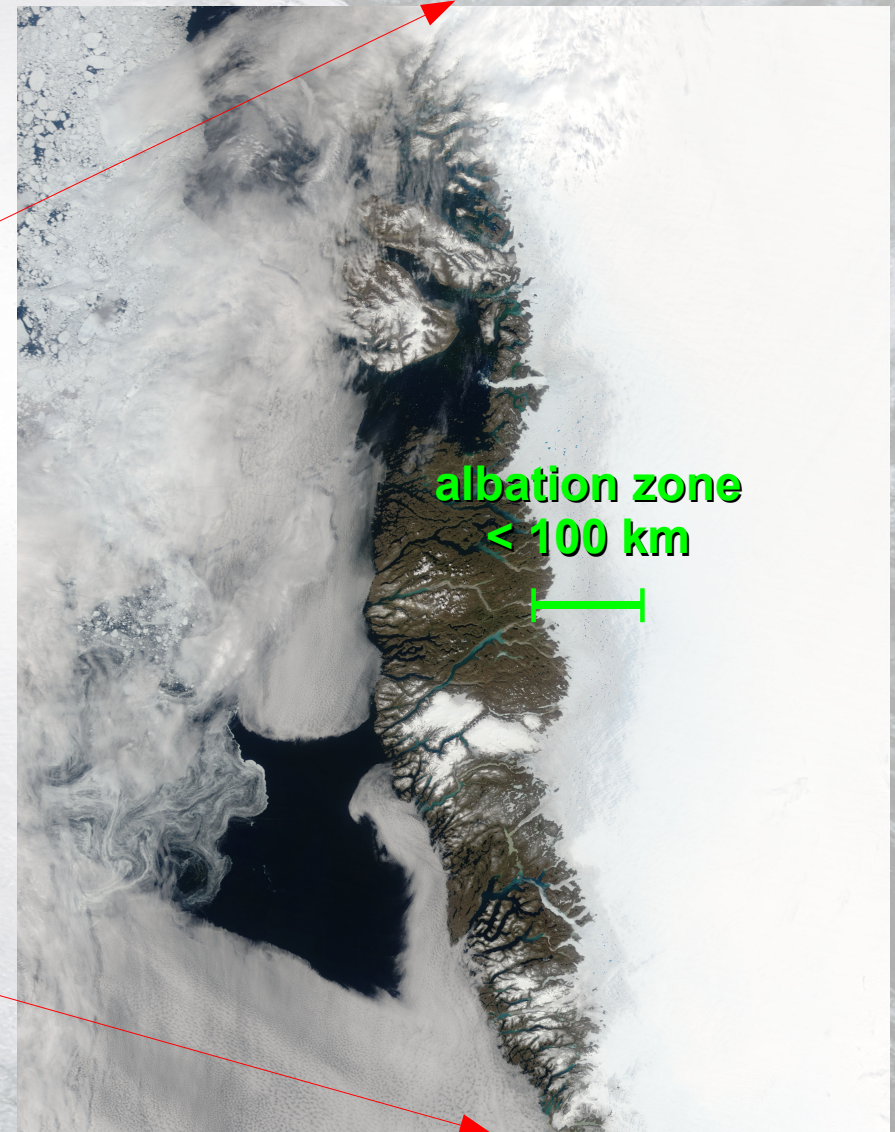
Albedo feedback



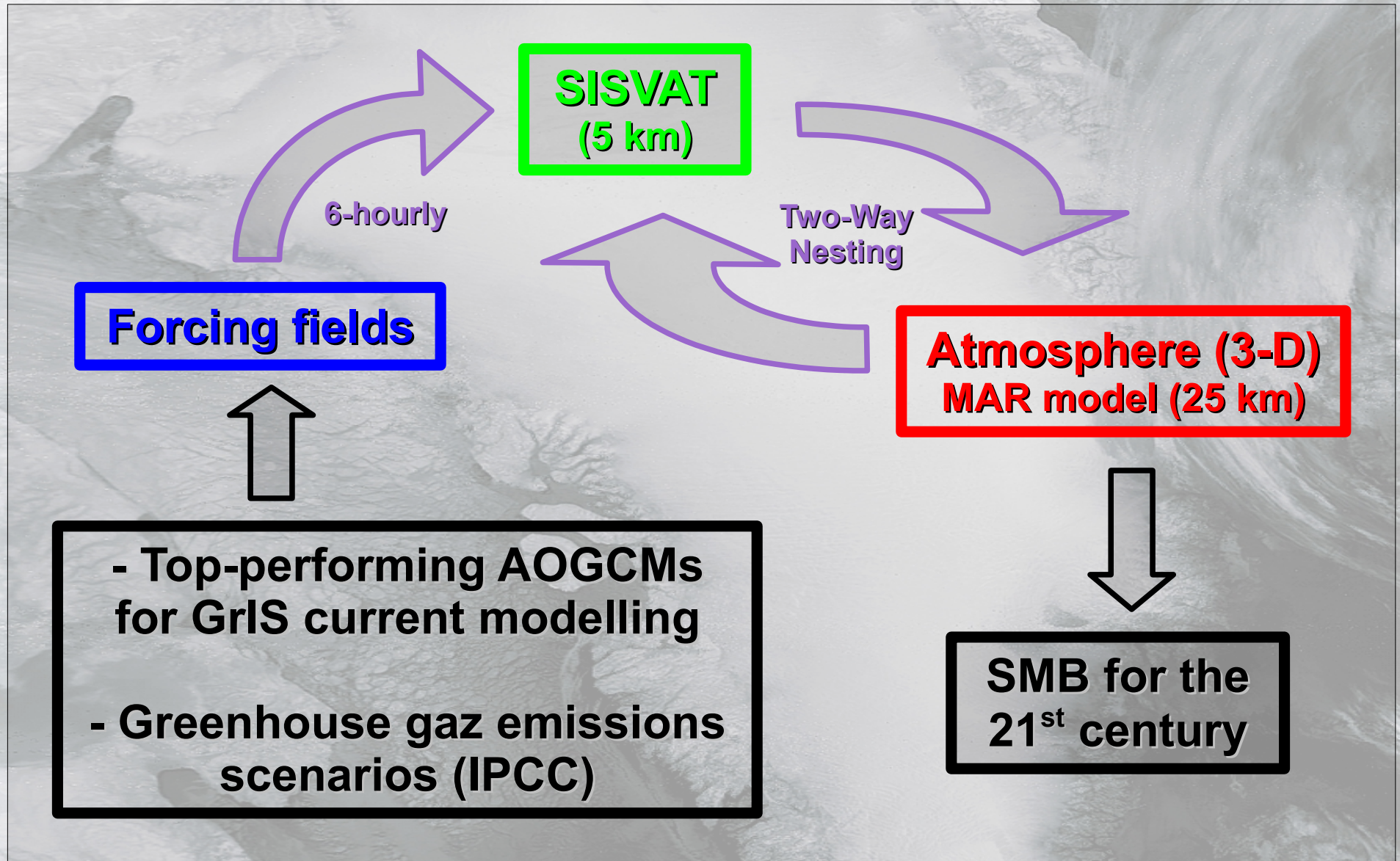
3.2 Interface de couplage 25 km \rightarrow 5 km



≈ 2000 km



3.3 Simulations futures



4. Perspectives de recherche

**Interface 25 km → 5 km
SISVAT**

**Regional Climate
Model**

Ice sheet model

**Blowing snow
module**

